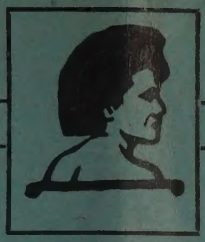
VOL. 30 NO. 2 JUNE, 1960



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Agricultural Journal

VOL. 30 JUNE, 1960 NO. 2

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AGRICULTURAL JOURNAL

So many requests are received for parts of the " Agricultural Journal " which were never published or which are now out of print, that the following list of all issues published is given for reference. Those volumes and numbers which are not now available are marked with an asterisk. It will be noted that copies of all parts of 17 volumes and parts of five other volumes are unobtainable. Should any reader have unwanted copies of these publications, the Librarian would be grateful to receive them.

Vol.			
1.	3	numbers,	1928.
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	No issue for 1958.		
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AGRICULTURAL CIRCULAR, 1920-25

NUMBERS and year of issue of the " Agricultural Circular " :—

Vol. 1, 1920, 12 numbers.
2, 1921, 5 ,,
3, 1922, 4 ,,
Vol. 4, 1923, 1 number.
5, 1924-5, 2 numbers.

As number 4 of Vol. 3 was printed as " Volume 4 " and number 1 of Vol. 4 as " Volume 5 " it would appear from an inspection of a complete set that Volume 4 comprised only a number 4 and that there were two issues of Volume numbered as 5, No. 1.

AGRICULTURAL BULLETINS

A FEW copies of the following bulletins are available at the prices shown. Other Bulletins previously listed are out of print.

No. 26. Mechanisation of Rice Padi Cultivation by R. R. Mason. Price 2s. 6d.
27. Index to Agric. Journal. Vols. 1–21 by B. E. V. Parham. Price 2s.
28. Soil Erosion and its Control in Fiji, by C. E. Whitehead. Price 2s.
29. Annual Reports of Divisional and Specialist Officers 1954. Price 4s.
30. The Grasses of Fiji, by J. W. Parham. Price 5s.
31. The Declared Noxious Weeds of Fiji and their Control, by T. L. Mune and J. W. Parham. Price 2s. 6d. (Revised Edition).
32. Copra Driers by G. B. Gregory, V. E. Sills and J. A. Palmer. Price 3s.
33. The Koronivia Farm Institute by R. L. Hartley. Price 3s.
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35. The Weeds of Fiji by J. W. Parham. Price 5s.
36. Annual Reports of Divisional and Specialist Officers, 1958. Price 4s.

AGRICULTURAL REPORTS

RECENT reports on Agricultural subjects are available as follows :—

Report by Sir Geoffrey Clay on his Visit to Fiji in 1954. C.P. No. 31, 1955. Price 1s. 6d.
The Fisheries Industries of Fiji. C.P. No. 1, 1956. Price 1s.
Department of Agriculture Annual Report for 1955. C.P. No. 8, 1956. Price 2s.
Department of Agriculture Annual Report for 1956. C.P. No. 8, 1957. Price 2s.
Department of Agriculture Annual Report for 1957. C.P. No. 18, 1958. Price 2s.
Department of Agriculture Annual Report for 1958. C.P. No. 9 of 1959. Price 2s.
Department of Agriculture Annual Report for 1959. C.P. No. 21 of 1960. Price 2s.

OTHER PUBLICATIONS

The Coconut Moth in Fiji, by J. D. Tothill, H. C. Taylor and R. W. Paine. Imperial Bureau of Entomology, 1930. Price £1.
The Fishes of Fiji, by H. W. Fowler. Government Printing Office, Suva. Price £3 10s. 0d.

EDITORIAL . . .

In this number the Senior Entomologist has reviewed the efforts made by this Department during the past ten years to reduce the incidence of certain of our pests by biological methods.

From its formation in 1906, the Department of Agriculture in Fiji has achieved almost classical success along these lines and every effort is still being directed along this line of research, which, when successful, has the great advantage of being permanent.

During the period between the two wars a number of highly toxic chemical sprays and fumigants were produced and whilst, in some cases, their use has proved of great value, in many cases it has been found that they have also led to the destruction of the natural enemies of the special pest against which they were intended, leading later to a renewed and rapid increase of the pest without the check imposed by its natural enemies, whilst, in others, it has been found that after a while the pest develops an immunity to one or more of these chemical agencies.

Even worse has been the destruction of insectivorous birds which, feeding upon the poisoned insects, have ingested a sufficient quantity of the poison to themselves succumb.

Today much attention is again being directed towards the use of biological methods, even against such vectors of disease as mosquitoes, against which Marshall Laird is obtaining encouraging results from the use of parasitic fungi and bacteria.

The article in this number, prepared by the Senior Entomologist, shows that the Department has not in any way relaxed its efforts along these lines.

—H.W.S.

STAFF NOTES

Mr. B. A. O'Connor, Senior Entomologist, has been seconded to the South Pacific Commission from 1st May, 1960, as part-time Consultant to assist in the campaign against the Coconut Rhinoceros Beetle.

Mr. J. W. Parham, Botanist, has also been seconded to the South Pacific Commission as temporary Plant Exploration and Introduction Officer ; the secondment is for a period of six months from 1st May, 1960.

Mr. Parham left Fiji early in May for a tour embracing the New Hebrides, Australia, Papua–New Guinea and New Caledonia.

Congratulations are extended to Mr. K. J. Garnett, Veterinary Officer, who has successfully completed his course at the Imperial College of Tropical Agriculture, Trinidad, and has been awarded the D.T.A. (Trin.).

PEST AND DISEASE CONTROL . . .

A DECADE OF BIOLOGICAL CONTROL WORK IN FIJI

BY B. A. O'CONNOR

In a previous issue of this Journal (O'Connor, 1950) an account was given of biological control of insects and plants in Fiji up to the year 1949. This article deals with work which has been carried out since then, and a table showing all introductions to date is appended.

CONTROL OF PENTATOMID AND COREID BUGS

In December, 1949, one hundred puparia of the Tachinid fly, *Trichopoda pennipes* F., were received from Florida (O'Connor, 1950). These were forwarded by Dr. F. J. Simmonds, of the Commonwealth Institute of Biological Control. The main purpose of introducing this insect, which is a parasite of various species of Pentatomid and Coreid bugs, was to attempt its establishment in the Solomon Islands, in the hope that it might bring about control of *Amblypelta cocophaga* China, a Coreid which causes heavy premature nutfall in coconut palms. The fly was bred through several generations and a strong colony was taken to the Solomon Islands and liberated there. So far as is known, it did not become established. In Fiji, a liberation of 50 males and 60 mated females was made at Nasinu on June 13, 1950. A few other small lots were also liberated, mainly in the vicinity of Naduruloulou, including one lot of 200 parasitized *Nezara viridula*, which were sent to Labasa, on the island of Vanua Levu. During October, 1950, a male *T. pennipes* was bred from field-collected bugs, and eggs of the parasite were found on an adult of *N. viridula* collected in the field. However, the parasite has apparently not established itself in Fiji.

CONTROL OF THE RICE ARMYWORM

During April, 1950, two species of parasites which attack the caterpillars of Noctuid moths were introduced from Hawaii, by courtesy of the Hawaiian Sugar Planters' Association (O'Connor, 1951). The primary purpose of the introduction was to bring about improved control of the Rice Armyworm, *Pseudaletia separata* Walk. Importations comprised eleven hundred cocoons of the Braconid, *Apanteles marginiventris* Cress., and one hundred puparia of the Tachinid, *Eucelatoria armigera* Coq. Most of the adults of *A. marginiventris* which emerged from the cocoons were liberated in the field, a few being kept in the insectary to determine whether they would breed on larvae of *P. separata*. The breeding test was successful. *A. marginiventris* very quickly became established in the field, and spread rapidly over the island of Viti Levu. Eight months after the first liberation, the parasite was found eighty miles from the liberation site. It is attacked by various species of hyper-parasites, so that only 50 per cent of the cocoons produce adult Apanteles, but nevertheless it is widespread and numerous.

Eucelatoria armigera apparently has not established itself in Fiji. Only 30 adults were liberated, and the entire breeding stock was wiped out by bacterial disease. No further colonies have been imported from Hawaii, because it is only rarely that the parasite can be found there.

In October and November, 1956, three shipments of the Tachinid, *Achaetoneura archippivora* Will., comprising between 400 and 500 adult flies, were received from Hawaii, by courtesy of the Division of

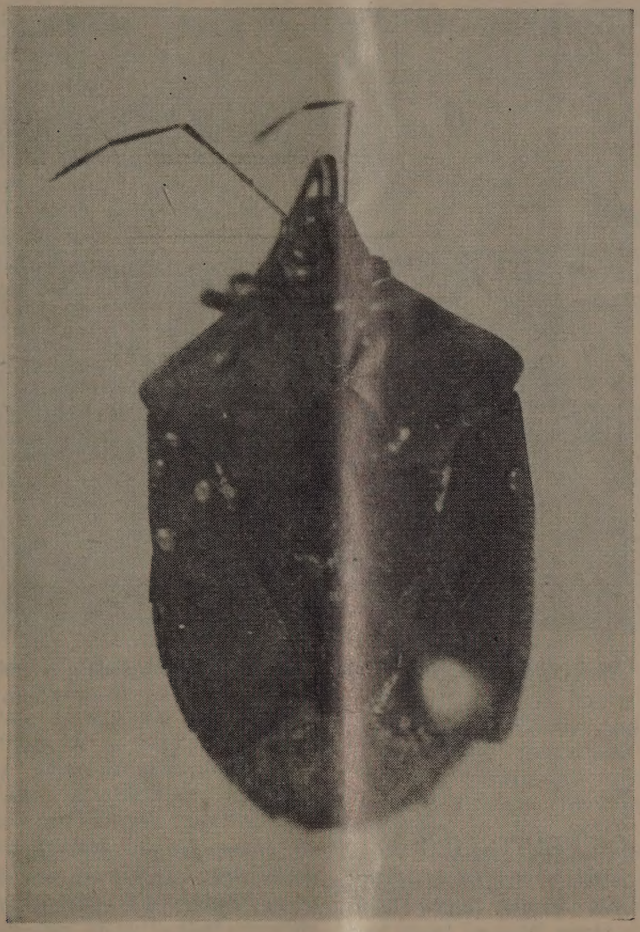

Plate 1—Eggs of *Trichopoda pennipes* on a host bug
Photo—B. A. O'Connor

Entomology and Marketing, Board of Commissioners of Agriculture and Forestry (O'Connor, 1959). This fly has a very wide host range and is easy to breed. Large numbers were bred and liberated during a period of eight months, when breeding operations were terminated. During this time 8,000 flies were liberated on the island of Viti Levu (at Koronivia and Tamavua), 230 on Vanua Levu (at Savu Savu) and 1,300 on Taveuni (at Waiyevo and Qilai). It is a surprising fact that the parasite has never been recovered from the field, even though it bred freely in the insectary on *Prodenia litura, Spodoptera mauritia* and *Heliothis armigera*. Owing to scarcity of armyworms, we did not determine whether it was capable of using them as a host.

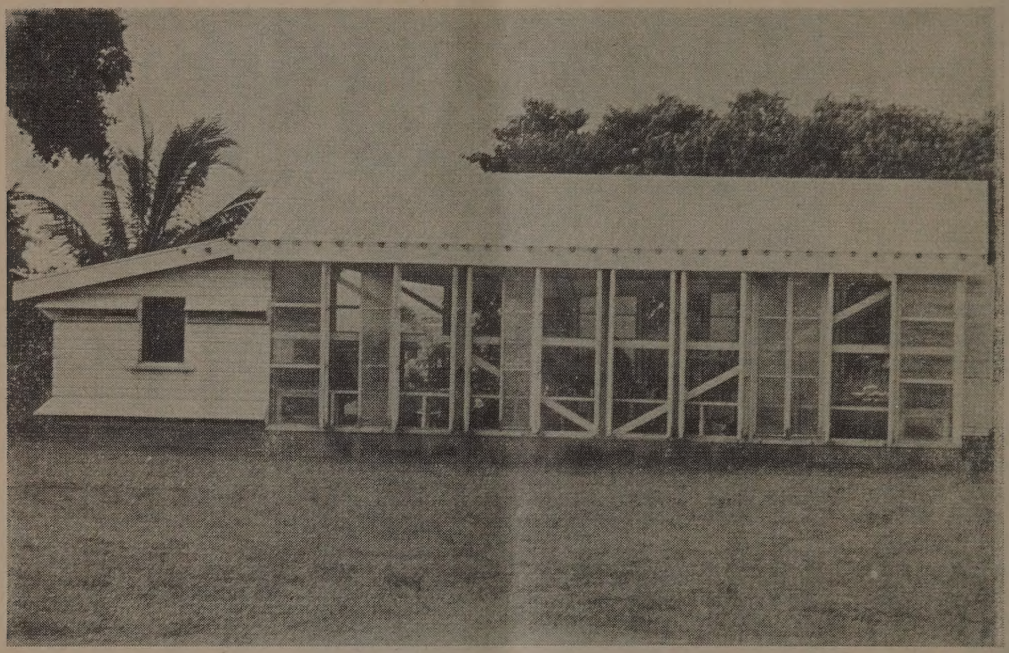

Plate 2—Insect-proof room and insectary where parasite breeding is conducted
Photo—B. A. O'Connor

CONTROL OF FRUITFLIES

The two pest species of fruitflies in Fiji are *Dacus passiflorae* Frogg. and *Dacus xanthodes* Broun. Since Hawaii had had considerable success in biological control of *Dacus dorsalis* Hend., it was decided to import parasites from that territory (O'Connor, 1952). These were kindly supplied by the Division of Entomology and Marketing, Board of Commissioners of Agriculture and Forestry. Liberations made during March and April, 1951, included 7,000 *Opius vandenboschi* Full., 650 *Opius oophilus* Full., and a few *Opius longicaudatus* Ashm. and *Opius incisi* Silv. Further consignments of parasites were received from Hawaii in March, 1954 (O'Connor, 1954), and the following liberations were made : 928 *Opius oophilus* and 726 *Opius longicaudatus*, of the sub-species *Taiensis, novocaledonicus* and *formosanus*. Breeding of *O. longicaudatus* was carried on for several months, using *Dacus passiflorae* as the host, no attempt being made to separate the three sub-species. As a result of the breeding work, a further 2,463 *O. longicaudatus* adults were liberated. Both *O. oophilus* and *O. longicaudatus* have become established in the field. During July and August of 1959 collections of fruitfly puparia from oranges and grapefruit were made and yielded 1,503 *Dacus passiflorae*, 411 *Opius oophilus* and 6 *Opius longicaudatus*. In the opinion of H. W. Simmonds, O.B.E., who has made a study of local fruitflies over the years, infestation of fruits is now very much less than it was ten years ago. It seems likely that *O. oophilus* has been responsible for a considerable measure of control of fruitflies.

CONTROL OF BANANA SCAB MOTH

The Banana Scab Moth, *Nacoleia octasema* Meyr., causes heavy losses of exportable fruit. It can be controlled by applying insecticides, but the peasant farmers who produce the bulk of banana exports carry out insecticidal applications very inefficiently. Hence control by parasites is very desirable. In 1950, G. S. Dun, Senior Entomologist, Department of Agriculture, Territory of Papua–New Guinea, reported the presence of a Tachinid parasite of the Scab Moth in New Britain. This was later identified as *Bactromyia frannseni* Baranov, a species with rather a wide range of hosts.

Towards the end of 1952 the writer spent two months in New Britain in an attempt to introduce *B. frannseni* to Fiji. However, the flies could not be induced to mate, with the result that no introduction was made. A Bethylid parasite of the Scab Moth larva, *Goniozus triangulifer* Kieff., was found, and proved easy to breed. It was brought back of Fiji and bred on Scab Moth larvae. In January, 12 male and 50 female wasps were liberated, but shortly afterwards the insectary colony died out, due to an inordinately high mortality rate among the host larvae and the production of a very high percentage of males. There is no evidence that the species became established. In any case, one would not expect particularly good results from a Bethylid, as wasps of this family appear to attack an extremely wide range of hosts, including members of different orders of insects. In 1958, a few *Bactromyia* and *Goniozus* were sent from New Britain by R. W. Paine and an attempt was made to breed them, but with no success.

In 1953 some puparia of *B. fransseni* were sent to Fiji by Dun, and 24 adults were liberated. There is no evidence that the parasite became established in the field.

En route to Rabaul, the writer had spent three days at Lae, on the mainland of New Guinea. During a tour of the surrounding district, where there is considerable cultivation of bananas, no sign of Scab Moth was seen. As the species had been recorded from the New Guinea mainland, it appeared likely that it was under efficient control by parasites. Hence it was decided that an investigation in this area might be fruitful. Nothing was done until 1956, when we were fortunately able to obtain the services of R. W. Paine, who had previously worked in Fiji with the team of entomologists who brought about biological control of Levuana Moth, Coconut Scale and Coconut Leaf Miner.

Paine arrived in New Guinea in November, 1956, and for some time was unable to find any Scab Moth. Finally he discovered that it was breeding on *Heliconia*, *Pandanus* and *Nipa*. He found seven species of primary parasites, of which much of the most promising was a polyembryonic Encyrtid, *Pentalitomastix nacoleiae* Eady. This insect oviposits in the eggs of its host and the parasite larvae develop within the larva of the host, finally killing it in the prepupal stage. Some hundreds of adult parasites emerge from each parasitized prepupa (Paine, 1957–58).

In June, 1957, the first lot of *P. nacoleiae* was received in Fiji. During the following nine months the parasite was bred in very large numbers on larvae of the Banana Scab Moth, and the progeny of approximately 4,300 parasitized prepupae were liberated. Hence the total number of individual wasps liberated amounted to something of the order of one million. Only a dozen parasitized prepupae were recovered in the field. These were from plants which were at the site of liberation, and which carried eggs of *N. octasema* at the time of liberation. They produced only male parasites. No other recoveries were made, even from Pandanus swamps, where some liberations were made during the flowering season when considerable infestations of Scab Moth were in being.

Paine's contract expired in April, 1958, and he found it necessary to return to the United Kingdom. Subsequently a new project of investigation was approved, finance being provided mainly by the Commonwealth Development and Welfare Fund. Paine agreed to continue work on the project, and arrived in Malaya during April, 1959. He has made a survey in Malaya and throughout the islands of

Indonesia which shows that *N. octasema* occurs throughout the region on *Pandanus* and *Nipa*, but only in Java, Bali, the Banda group, Flores and Timor has Paine so far found it on bananas (Paine, 1959).

The failure of *Pentalitomastix* in the field, after it has bred freely on banana-feeding Scab Moth larvae in the insectary, suggested the possibility that this parasite did not frequent the banana plant. Paine's recent work in Java seems to support this hypothesis, as he has found two species of parasites of *N. octasema* on Nipa palm which apparently do not occur on banana plants. Hence it would appear necessary to seek parasites which frequent the banana.

Plate 3—*Chelonus striatigena* ovipositing in egg of Banana Scab Moth

Photo—B. A. O'Connor

Fortunately Paine has found such a parasite in Flores and Timor. It is a species of *Chelonus*, which oviposits in the egg of the host and develops within the larva. The host larva spins its cocoon early, and a single parasite larva emerges and constructs its own cocoon under that of the host. During January and February of 1960, Paine sent five consignments of parasite material, the product of breeding operations in Java, from which approximately 250 male and 350 female *Chelonus* adults emerged. Most of these were liberated, and the remainder used for local breeding, which is now in full swing.

CONTROL OF THE RHINOCEROS BEETLE

The presence of *Oryctes rhinoceros* L. in Fiji was first discovered in 1953. For several years thereafter the low populations of the pest and the treatment of breeding places with B.H.C. provided an unfavourable environment for the introduction of parasites of *Oryctes*. Consequently, more emphasis was placed on predators, as these are capable of maintaining themselves on hosts other than the Rhinoceros Beetle.

In 1953, by courtesy of N. L. H. Krauss and other officers of the Division of Entomology and Marketing, Board of Commissioners of Agriculture and Forestry, Honolulu, consignments of the Hesterid beetles, *Leionota* spp. (*L. colombiana, L. quadridentata* and probably another species) were received from Trinidad. About 4,850 of these were liberated. Laboratory tests showed that the beetles would feed on grubs of *Oryctes, Rhopaea, Cosmopolites* and others, and that they lived for as long as five months. In 1954, Krauss sent more *Leionota* spp. of which 2,300 were liberated and, in 1955, large numbers of *Leionota* spp. were also sent from Trinidad by the Commonwealth Institute of Biological Control, about 9,200 of these being liberated. Thus, in the period 1953–55, about 16,500 adults of *Leionota* spp. were released in the south-eastern corner of Viti Levu. They have not since been recovered in the field.

In 1954 the Carabid, *Mecodema spinifer*, was sent from New Zealand by courtesy of the Cawthron Institute. This importation was arranged by H. W. Simmonds, O.B.E., who liberated 60 of the beetles. However, he was of the opinion that they might fall a prey to the giant toad, *Bufo marinus*, as the beetles are flightless.

Dr. C. P. Hoyt, of the South Pacific Commission, sent two lots of the predatory beetle *Scarites madagascariensis* from Madagascar in 1957. Many died *en route*, a total of 265 being liberated.

In addition to predatory beetles, parasitic wasps of the genus *Scolia* have been introduced into Fiji. During the early years of the campaign against *Oryctes*, which began

Plate 4—Rhinoceros beetle with parasites and predators introduced into Fiji for its control

Photo—B. A. O'Connor

in 1953, conditions were unfavourable for the establishment of parasites whose only host in Fiji is *Oryctes rhinoceros*, because populations of the pest were very low and known breeding places were regularly treated with B.H.C. Nevertheless, two shipments of *Scolia oryctophaga* Coq. were obtained from Mauritius in September, 1954. These arrived in excellent condition, and over 750, almost all females, were liberated. In September, 1959, another small lot arrived from Mauritius, 15 males and 39 females being liberated. There is as yet no evidence of establishment.

In May, 1958, a consignment of 232 cocoons of *Scolia ruficornis* F. was received from R. P. Owen, of the American Trust Territory of the Pacific Islands. These were taken over by H. W. Simmonds, O.B.E., who has conducted the breeding and distribution of this parasite since. Breeding has been carried on in prepared compost heaps in the field, and has been quite satisfactory. Though no cocoons have been recovered in natural breeding places, it seems very likely that the parasite has now established itself in Fiji. The present level of distribution and incidence of the Rhinoceros Beetle on the island of Viti Levu is such as to provide adequate breeding material for the parasite.

In 1957, Dr. Paul Surany, of the South Pacific Commission, forwarded colonies of two species of Nematodes, which prey on *Oryctes*, from Ceylon and Madagascar respectively. These belong to the genus *Rhabditis*. In the insectary they attack grubs, pupae and adult beetles, and also grubs of other Lamellicorn beetles. They have been bred and liberated continuously since they were first received, and on one occasion the Ceylon species has been found in an *Oryctes* grub collected in the field.

CONTROL OF COCKROACHES

Cockroaches parasitized by the wasp *Tachypulex compressa* Fabr. were imported from Hawaii in September, 1955. Two male and two female wasps emerged, and oviposited on local cockroaches, but the locally bred generation comprised only three male wasps.

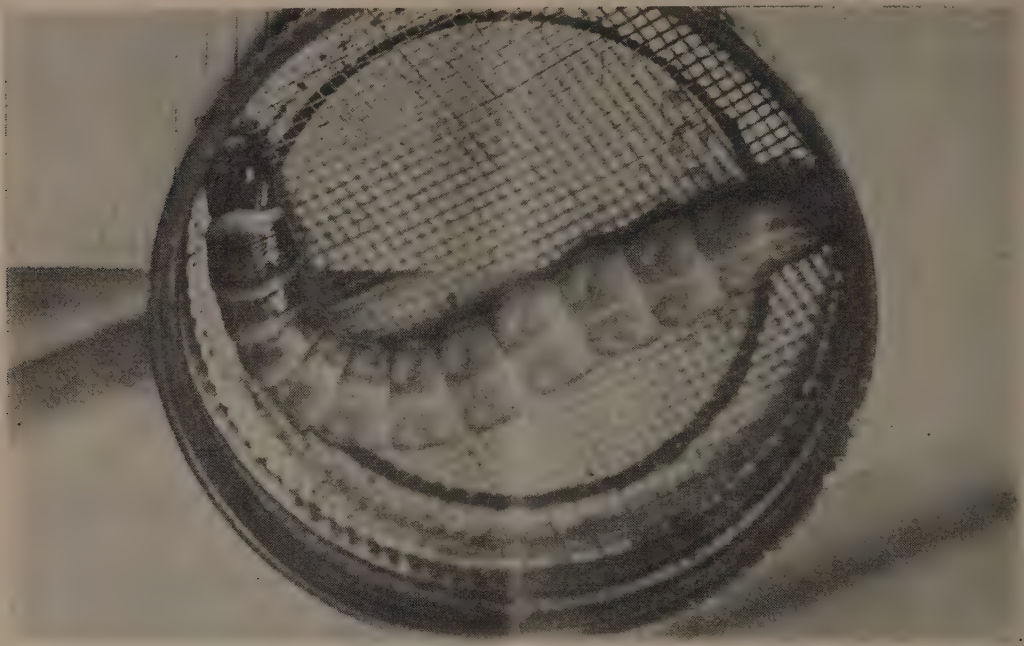

Plate 5—Larva of *Pyrophorus* sp., an imported predator on *Oryctes rhinoceros*

Photo—B. A. O'Connor

CONTROL OF THE COCONUT STICK INSECT

In August, 1956, the Forestry Commission of New South Wales forwarded 152 eggs of the Phasmid, *Ctenomorphodes tessulata* Gray, parasitized by the Cleptid wasp, *Myrmecomimesis rubrifemur* Riek. From these eggs 33 male and 29 female wasps emerged and an attempt was made to breed them on the eggs of the Coconut Stick Insect, *Graeffea crouani* Le Guill., but without success.

CONTROL OF THE SMALL COCONUT LEAF MOTH

During the visit of the writer to New Britain in 1952, an effort was made to find parasites of *Agonoxena pyrogramma* Meyr., which feeds on the leaflets of coconut palms in the Territory of Papua–New Guinea but occurs in only very small numbers. It was thought that parasites of this moth might be useful in controlling *Agonoxena argaula* Meyr., the Small Coconut Leaf Moth, which causes appreciable loss of leaf tissue on coconut palms in Fiji. While no assessment of losses caused by this pest has been made, it is universally present on palms here. It is thought that it significantly retards the growth of very young palms, and occasionally the insect has been known to cause severe damage to mature palms. Two parasites were found, namely a species of *Apanteles* and a Dipterous parasite of which no adults were bred out.

During 1957 and 1958, Paine was able to devote some time to an investigation of the parasites of *Agonoxena* in New Guinea and New Britain. In addition to the two species already known, he found other species of parasites, including two more species of *Apanteles*, a *Bracon* sp. and an *Elachertus*

sp. The Dipterous parasite proved to be a small Tachinid, as yet unnamed. Material of all these species was forwarded to Fiji, where attempts to breed them met with little success. The Tachinid and *Elachertus* were thought to be the most promising species, as we already have an *Apanteles* and a *Bracon* parasitic on *Agonoxena* in Fiji. A total of 23 male and 92 female *Elachertus* were liberated in the field. No other liberations were made, except for a token lot of 4 male and 3 female *Apanteles* sp. Twenty-five adult Tachinids emerged from puparia, but all died within 24 hours. It is hoped that Paine may be able to study this Tachinid in New Britain in 1960.

CONTROL OF NOOGOORA BURR

Noogoora Burr (*Xanthium pungens*) is a troublesome weed in the western districts of Viti Levu and is one of the Declared Noxious Weeds of Fiji. It was decided that an attempt should be made to import from Queensland the seedfly *Euaresta aequalis* Loew, which was an introduction to Queensland from the United States of America (O'Connor, 1953). This fly has not proved successful in controlling the weed in Queensland, where fruiting is seasonal, but it was thought that it might be more effective in Fiji, where seeds are formed throughout the year.

Arrangements for the collection of burrs were made with A. P. Dodd, of the Biological Section, Department of Public Lands, Brisbane. Dissection of the burrs was carried out by University students on vacation, kindly recruited by F. A. Perkins, Lecturer in Entomology at the University of Queensland. The writer visited Brisbane in early February, 1951, and brought back to Fiji larvae and puparia of the seedfly. Between February 8 and April 7 a total of 2,049 flies (1,033 males and 1,016 females) were liberated in the Sigatoka area, but, as far as is known, the fly failed to become established.

CONTROL OF LANTANA

In 1952, Fiji made a financial contribution to a scheme for biological control of *Lantana camara*, a Declared Noxious Weed, the other contributors being Australia and Hawaii. The headquarters of the project was in Honolulu, the scheme having been organized by the Division of Entomology and Marketing, Board of Commissioners of Agriculture and Forestry, Hawaii. Since the project began, several species of insects have been forwarded to Fiji, after having been subjected to feeding tests in Hawaii (O'Connor, 1957).

In 1954, consignments of the moth *Lepharomastix acutangulalis* Snellen were received and breeding and distribution continued until April, 1956. About 600 moths and 2,000 larvae were liberated at Nasinu during this period, but there is no indication that this insect has become established. In 1954 and 1955 we received the moth *Diasema tigris* Guen., but only a few small releases were made without any evidence of establishment. As it was understood that these two species had been unsuccessful in Hawaii, no further effort was made with them.

In 1956 twenty-five adult Longicorn beetles of the species *Aerenicopsis championi* Bates were imported. This beetle was bred through one generation, taking over seven months, but it was obvious that no significant increase in numbers could be obtained. In the absence of large numbers for field liberations, work on this species was dropped. In 1956 we received a lot of the beetle *Octotoma scabripennis* Guerin. These fed freely on the leaves of Lantana

Plate 6—Lantana leaves damaged by larvae of *Syngamia haemorrhoidalis*

Photo—B. A. O'Connor

and lived as long as eight weeks, but produced no eggs. No further importations were made.

In 1958 and 1959 importations were made of the leaf-rolling moth, *Syngamia haemorrhoidalis* Green, which has done good work in Hawaii. Breeding was carried on in the insectary, and about 1,200 moths were liberated over a period of eighteen months. In November of 1959 the insect was found in the field in various localities in the Suva–Nausori area and appears to be well established. Towards the end of the year, seven lots of moths, totalling 665, were sent to Savusavu, on the island of Vanua Levu.

CONTROL OF TOBACCO WEED

During March and April of 1957 shipments of the seedfly, *Tetraeuaresta obscuriventris* Lw., were received from the Commonwealth Institute of Biological Control in Trinidad for trial in control of Tobacco Weed, *Elephantopus mollis*, also a Declared Noxious Weed. Adult flies and large quantities of seedheads were sent. No attempt was made to breed the fly in the insectary, but about 7,000 adults were liberated in the field. The insect quickly became established, and is now to be found in vast numbers throughout the island of Viti Levu. As the weed is a prolific seeder, one cannot foretell just what effect will be produced by *Tetraeuaresta*, and it will probably be several years before we know the answer.

At the end of this article is a table showing introductions of beneficial insects since 1950. The insects listed are only those of which liberations were made in the field. There is also a table containing records of the establishment in Fiji of beneficial insects which were introduced prior to 1951 and of which the observation of establishment has occurred since 1949.

Plate 7—Adult of *Cryptognatha nodiceps*, introduced and established for the control of Coconut Scale, *Aspidiotus destructor*

Photo—B. A. O'Connor

Plate 8—Larva of *Cryptognatha nodiceps* on scale-infested leaf

Photo—B. A. O'Connor

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BENEFICIAL INSECTS INTRODUCED TO FIJI AND LIBERATED, 1951–60

Year	Beneficial Species	For Control of	Introduced from	Remarks
1951, 1954	*Opius oophilus* Full.	*Dacus* spp.	Hawaii	Established
1951	*Opius vandenboschi* Full.	*Dacus* spp.	Hawaii	
1951, 1954	*Opius longicaudatus* Ashm.	*Dacus* spp.	Hawaii	Established
1951	*Opius incisi* Silv.	*Dacus* spp.	Hawaii	....
1951	*Euaresta aequalis* Loew.	*Xanthium pungens* Wallr.	Queensland	....
1952, 1958	*Goniozus triangulifer Kieff*	*Nacoleia octasema* Meyr.	New Britain	....
1953, 1954, 1955	*Leionota* spp.	*Oryctes rhinoceros* L.	Trinidad	....
1953, 1955	*Pyrophorus* spp.	*Oryctes rhinoceros* L.	Trinidad	....
1953	*Bactromyia fransseni* Baranov	*Nacoleia octasema* Meyr.	New Britain	....
1954	*Blepharomastix acutangulalis* Snellen.	*Lantana camara* L.	Hawaii	....
1954	*Diastema tigris* Guen.	*Lantana camara* L.	Hawaii	....
1954	*Mecodema spinifer*	*Oryctes rhinoceros* L.	New Zealand	....
1954, 1959	*Scolia oryctophaga* Coq.	*Oryctes rhinoceros* L.	Mauritius	....
1956	*Achaetoneura archippivora* Will.	*Pseudaletia separata* Walk.	Hawaii	....
1957	*Pentalitomastix nacoleiae* Eady	*Nacoleia octasema* Meyr.	New Guinea	....
1957	*Tetraeuaresta obscuriventris* Lw.	*Elephantopus mollis* H.B.K.	Trinidad	Established
1957	*Scarites madagascariensis*	*Oryctes rhinoceros* L.	Madagascar	....
1957	*Rhabditis* spp.	*Oryctes rhinoceros* L.	Madagascar — Ceylon	....
1958	*Elachertus* sp.	*Agonoxena argaula* Meyr.	New Guinea	....
1958	*Apanteles* sp.	*Agonoxena argaula* Meyr.	New Britain	....
1958	*Syngamia haemorrhoidalis* Guen.	*Lantana camara* L.	Hawaii	Established
1958	*Scolia ruficornis* F.	*Oryctes rhinoceros* L.	Palau Islands	....
1960	*Chelonus striatigena* Cam.	*Nacoleia octasema* Meyr.	Timor and Flores	....

BENEFICIAL INSECTS INTRODUCED PRIOR TO 1951 AND OBSERVED TO BE ESTABLISHED AFTER 1949

Year	Beneficial Species	For Control of	Introduced from	Remarks
1927	*Aleurodothrips fasciapennis Franklin*	*Aspidiotus destructor* Sign.	Java	Established
1935	*Trathala (Cremastus) flavo-orbitalis* Cam.	*Pyralidae*	Hawaii	Established
1938	*Melittobia indicum* Silv.	*Dacus* spp.	Australia	Established
1950	*Apanteles marginiventris* Cress.	*Pseudaletia separata* Walk. and other Noctuids.	Hawaii	Established

AGRONOMY . . .

THE MAINTENANCE OF SOIL FERTILITY IN FIJI

3. BANANA-GROWING AND THE SPECIAL REQUIREMENTS OF THE BANANA PLANT

BY N. G. CASSIDY

The present article is the third of a series by the author (Cassidy and Pahalad, 1953) in which consideration is given to the problem of maintaining soil fertility under tropical conditions and at the same time obtaining profitable crops from the land.

The first part dealt with the results of native subsistence agriculture and the second with commercial exploitation for canned pineapples.

Consideration is now given to the growing of bananas for export and to the almost unique position of the banana in regard to its nutritional requirements.

It is a general rule that the different parts of a plant vary in their composition according to their function, starch being present in storage organs, lignin where strength is required and so on. In the same way it is also found that the major nutrient elements, nitrogen, phosphorus and potassium, are also variable in their distribution within the plant and consequently vary in their ratios to each other from part to part. This is shown in the accompanying table. Note that only *relative proportions* are given.

TABLE I

RELATIVE PERCENTAGES OF NITROGEN, PHOSPHORUS AND POTASSIUM IN DEFFERENT PLANT PARTS OF VARIOUS SPECIES OF PLANTS.

(All relative to $P_2O_5 = 1$)

	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
Peanuts—			
Hay	[illegible]	1	5
Kernels	[illegible]	1	1
Rice—			
Straw	[illegible]	1	9
Grain	[illegible]	1	1
Cotton—			
Leaves	[illegible]	1	4
Bolls	[illegible]	1	18
Seed	[illegible]	1	1
Potatoes—			
Leaves	[illegible]	1	15
Tubers	[illegible]	1	1
Beet—			
Tops	[illegible]	1	14
Roots	[illegible]	1	4
Carrots—			
Tops	[illegible]	1	5
Roots	[illegible]	1	4
Corn—			
Leaves	[illegible]	1	4
Grain	[illegible]	1	[illegible]
Coconuts—			
Leaves	[illegible]	1	3
Nuts	[illegible]	1	6
Oil Palm—			
Leaves	6	1	6
Nuts	3	1	7

The banana, however, is a specialized plant in which the trunk consists not of an orthodox arrangement of phloem, cambium and xylem layers arranged concentrically, but of the extensions of the leaf stipulae folded about each other to form a pseudostem. It is therefore not surprising to find that the nitrogen : phosphorus : potassium ratio for the pseudostem is the same as for the leaves. It also happens that in the fruiting part, i.e., the bunch, the same ratio is maintained. It follows, then, that, contrary to most other plants, the banana has what is practically a constant ratio of the major nutrient elements throughout the whole plant, and even the age of the plant does not appear to do much to alter the ratio.

TABLE 2

THE RELATIVE CONSTANCY OF THE BALANCE OF MAJOR NUTRIENTS IN THE BANANA PLANT

(All items are in relative percentages referred to $P_2O_5 = 1$)

		Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
Young plant ..	Baillon	2	1	8
Mature Plant ..	Baillon	4	1	19
Leaves	Bouffil	4	1	9
Stem	Bouffil	3	1	8
Fruit bunch ..	Bouffil	4	1	9
Stems and Leaves	Brunnich	3	1	9
Fruit	Brunnich	4	1	14
Plants—				
Lady's Finger	Brunnich (Buderim)	4	1	12
Cavendish ..	Brunnich (Buderim)	7	1	25
Sugar . ..	Brunnich (Buderim)	3	1	11
Fruit—				
Lady's Finger	Brunnich (Buderim)	3	1	9
Cavendish ..	Brunnich (Buderim)	3	1	10
Sugar . ..	Brunnich (Buderim)	4	1	8
	Mean ratio ..	4	1	12

It therefore becomes very difficult to resist the conclusion that this ratio, among all the manifold variations of N, P, K, which could be proposed is, in fact, the optimum one for the correct nutrition of the banana plant and that such a nutrition ratio should produce both a good plant and a good bunch.

At this stage it must be made clear that the author's optimum value applies to the plant foods which are actually readily available to the plant. In the first case, it would not apply to the fertilizer to be used in a plantation without having consideration for the plant foods already available in the soil. It would also not apply without modification to plant foods which either need time to develop available forms in the soil, e.g., nitrogen in insoluble combination, or to plant foods which may become precipitated (such as soluble phosphates) when they are added to certain soils. It should, however, apply to the soluble nutrients required by banana plants grown in sand culture or in other inert material.

The difficulty of making use of such a ratio for the practical nutrition of banana plants grown under commercial conditions is obvious. However, it does give the very great advantage of knowing what to aim at,

even if the precision to be expected from the modifications necessary for any particular case may not be very great.

The unusual numerical value of the optimum ratio is sufficient to give it great usefulness, because it is obvious that the banana requires high potassium in association with low phosphorus nutrition. An average value for all cultivated plants is therefore quite unsuitable for the banana and the use of such a balance of nutrients could lead to poor results from fertilizers or to waste of money, or both of these. Indeed, French workers in the Côte d'Ivróire have stated that, in the nutrition of bananas, the use of phosphates can be definitely harmful.

The author's own work in Fiji has shown that a high level of exchangeable potassium is essential in a banana soil and that, even on rich alluvial soils, continued banana growing without fertilizer results in depleted potassium and poor yields, whilst available phosphate may remain quite unaffected.

THE DECLINE OF FERTILITY IN BANANA PLANTATIONS

These findings resulted from an investigation to find the reason for the quick decline of fertility that occurs in many Fiji banana plantings. A number of sites was chosen where there was a definite history of either well-maintained yields or of quick decline in yield. Soil samples were taken at each such site and, where possible, samples were also taken from adjacent virgin land of the same soil type. Care was taken to exclude instances where decline in yield might have been due to neglect of cultivation of drainage to disease, or to any such reasons. Table 3 (overleaf) gives the results.

An examination of Table 3 will show that the key to the maintenance of good yields is potash status. In the two cases where yields have decreased notably, it is potassium which has declined, whilst there has been no consistent change in nitrogen, phosphorus, calcium or magnesium.

Moreover, wherever yields have been good, the potash status has been good ; and when yields have been mediocre or poor the potash status has been lower.

In order to make the situation clearer, Table 4 simplifies the data by showing weighted means for the full depth of soil which was sampled.

The mean value of exchangeable potash for the good plantations was 0.58 milli-equivalent per 100 grams of soil, and for the corresponding plantations which showed a decline it was 0.25 milli-equivalents. The difference was statistically very highly significant.

Without more extensive data it is not possible to set a threshold value for the likely response of banana soils to potash fertilizer. It is sufficient to say that bananas need approximately twice the level of potassium that was shown to be sufficient for sugar cane by the Queensland Bureau of Sugar Experiment Stations (1939).

The importance in Fiji of weed control, especially of para grass, has been stressed by Yelf *et al.* (1957) whilst the need for good drainage, more especially for the Veimama variety, is pointed out by Cassidy (1959).

Meantime a systematic investigation of the fertilizer needs of bananas for high production on some of the more important Fiji soil types has begun, and a preliminary survey by McPaul is not inconsistent with the view that on young Rewa alluvial soils rich in potash and in phosphate, the dominant need is for nitrogen. This is consistent with the known needs of bananas, and indeed of a variety of crops, for high production on rich alluvial soils.

In the Canary Islands the fertilizer ratio adopted is $N : P_2O_5 : K_2O = 5 : 1 : 10$ which is very similar to the author's optimum. Here the soils were reported to be shallow and in need of heavy applications of fertilizer.

TABLE 3

THE NUTRIENT STATUS OF BANANA SOILS IN RELATION TO MAINTENANCE OF PRODUCTION

Farmer and Locality	Soil Type	History of land and yields	Depth (inches)	Total N (%)	Available P_2O_5 (ppm.)	Exchangeable cations (m. e. per 100 g.) K	Ca	Mg
Viliame, Burerua ..	Waidina . ..	Virgin site; lantana and bush for 20–25 years.	0–12	0·20	44	1·9	13·4	9·6
		Planted 9 years; decreased yield after 7 years.	0–12	0·25	39	1·46	16·4	8·7
Josua, Nabukaluka ..	Rewa	Planted 10 years; good yields maintained	0– 5	0·35	97	0·44	....	....
			5–18	0·15	37	0·20	....	....
		Planted 25 years; yields are now only one-third	0– 5	0·21	205	0·18	....	....
			5–18	0·12	129	0·10	....	....
Ratu Timoci, Nabouva	Rewa	Planted 10 years; still good yields ..	0–12	0·14	144	0·64	24·6	11·0
		Neglected (para grass)	0–12	0·25	46	1·23	21·4	11·9
Livai, Malabi	Rewa sand ..	Planted 5 years; yield decreasing ..	0–18	0·15	119	1·27	....	....
Livai, Natokalau ..	Lodoni	Virgin site (Not very typical) ..	0– 2	0·58	31	0·26	....	....
			2–18	0·12	14	0·33	....	....
		Planted 8 years; mediocre; type nearer to virgin soil.	0– 5	0·53	105	0·26	....	....
			5–18	0·20	50	0·08	....	....
		Planted 8 years; mediocre; was good for 2–3 years.	0– 5	0·45	23	0·26	....	....
			5–18	0·18	100	0·16	....	....
Usaia	Waidina . ..	Virgin site	0– 9	0·38	34	0·21	1·43	1·29
			9–18	0·16	36	0·13	0·90	0·68
		Planted 5 years; decreased yield; never very good	0– 9	0·35	27	0·22	3·10	2·08
			9–18	0·10	32	0·16	0·85	1·13

NOTE.—Each figure is the mean of three (or occasionally two) analyses.

TABLE 4

Soil Type	Period under bananas	Initial yields	Result of cropping	Potash content (m.e. per 100g.)
Waidina	Nil	Virgin	.....	1·19
	9 years	Good	Declined	0·46
Rewa	10 years	Good	Yield still good	0·27
	25 years	Good	Yields now one-third	0·12
Rewa	10 years	Good	Good yields still	1·64
Lodoni	Nil	Virgin	.....	0·27
	8 years	Good for 2–3 years	Mediocre	0·13
	8 years	Good for 2–3 years	Mediocre	0·19
Waidina	Nil	Virgin	.....	0·17
	5 years	Never good	Now very poor	0·19

DISCUSSION

Many Fijian banana plantations are allowed to become overgrown with weeds, particularly with Para grass (*Brachiaria mutica*). Under these conditions bananas produce crops which are not worth packing.

The present investigations have shown the special need for potash and it seems that, without abundant potash available to them, bananas cease to thrive whilst the ever-present Para grass is quite unaffected. The richer the soils are in phosphate the better the conditions for the grasses. At this stage the grower probably becomes discouraged as he is fighting a losing battle ; and the Para grass takes over.

It is possible that nitrogen may also be deficient, especially on the Rewa sandy alluvials ; but the indications are that potassium is the nutrient element that fails first. Fortunately the best potential banana soils in Fiji are initially well supplied with potassium ; otherwise their use for commercial banana-growing, carried on as it usually is without fertilizer of any kind, would be even more short-lived than it now is.

Although commercial banana-growing in the wet zones of Fiji seriously exploits the potassium resources of the soil, the land eventually reverts to Para grass and is not affected by erosion. After a resting period the land can be used again. For continuous cropping it will therefore be necessary to find the point in the cropping cycle where potassium has become the limiting factor and apply potash fertilizer to the new planting. It may of course be necessary to use other fertilizers for the preceding crops.

It will have been noted that this article has been concerned with the balance of plant foods when bananas are grown under the present system without the use of fertilizers.

By using fertilizers the present yields can undoubtedly be increased ; and on soils which are well supplied with potassium the increase will come from the use of other fertilizers, such as those rich in nitrogen.

The systematic investigation now in progress can be expected to define in terms of hundredweights of fertilizer per acre, the conditions for such increased yields, for each of the main banana-growing soils of the wet zone.

SUMMARY

The reason for the decline in yield of banana plantations in the wet zone of Viti Levu has been investigated.

Under the ruling system of production for export without the use of fertilizers, it appears that potassium is the first plant food to become deficient. Para grass then becomes dominant and yields of bananas are worthless.

Such a course of events is consistent with the special nutritional needs of the banana plant is outlined in this article.

The present system cannot be continued, even with a resting period for the land, and still maintain soil fertility.

Another investigation is in progress which should define the conditions for increased and continuous production by the use of fertilizers.

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RURAL INDUSTRIES . . .

4. PEPPER

BY V. E. SILLS

Unlike the previous products described in this series of articles—ginger, cassava starch and coffee—pepper has never been of any agricultural importance in the Colony. Pepper gardens have, however, been successfully established at the Experimental Station, Naduruloulou, from cuttings introduced from Sarawak in 1951.

Pepper is one of the earliest spices known to mankind and for many years it formed a staple article of commerce between India and Europe. Black pepper, the dried fruit of *Piper nigrum*, a perennial woody vine, came originally from South India and has been introduced into Java, Sumatra, Borneo, the Malay peninsula, Siam and the West Indies. Pepper is not considered an easy crop to grow but its requirements are undoubtedly well understood by the Chinese, for they have proved excellent pepper growers, particularly in Sarawak where production has steadily increased over the past ten years.

Stonehewer Cooper (1888) mentions pepper as being one of the commodities to be exported from Fiji in 1879 and 1880. Certainly, from the point of view of climate and soil, there is no serious reason why pepper should not be grown successfully in Fiji, and, in fact, the pepper gardens now established at Naduruloulou have done quite well (Parham 1954). Pepper does, however, appear to give best results under the wetter conditions found nearer to the Equator. According to Brown and Reader (1952) the pepper vine requires a hot, humid climate with an average rainfall of at least 50 to 100 inches per annum, fairly well

Plate 1—Pepper garden established at Naduruloulou

Photo—V. E. Sills

distributed since the plant cannot withstand periods of prolonged drought. In this connexion it is perhaps worth mentioning that the prolonged drought-like conditions experienced in Fiji between 1957 and 1958 was one of the main contributory causes of the failure of attempts by local planters to establish new pepper gardens about this time.

Another aspect of pepper production which must have been discouraging to many planters in the past few years has been the wide fluctuation in the market price of pepper since the war. Pepper has not been the only spice to be affected in this way. The market price of dried ginger, for example, has been particularly unstable (Prentice 1959), with the result that a period of high prices has caused farmers to over-produce ; this has been followed by a period of low prices and underproduction, and so on. As regards pepper, the London spot price of Sarawak black pepper in 1949 was 3s. 10d. per lb. Two years later it stood at 18s. 7½d. In 1953 the price was down to 8s. 9d. and by 1957 it had dropped to 1s. 5d. Early in 1960 the price was around 5s. per lb. with every sign of instability.

The volume of world trade in pepper was severely curtailed following the outbreak of war in 1939 and did not recover to its former level until 1956. In the meantime there were many changes in the sources of production. Whereas prewar, Indonesia produced three quarters of the world's supplies of pepper, recent production figures quoted by the Commonwealth Economic Committee (1958) show that Malaya, Sarawak and India now share with Indonesia the distinction of being the principal producing countries.

Another interesting, though perhaps less important, feature of pepper production concerns the recent trend towards the production of more black pepper at the expense of the white. For example, before 1952 nearly all of the pepper produced in Sarawak was of the white kind. But by 1956 the production of black pepper in Sarawak had risen to 86 per cent of the total. The reason given for this development is the growing demand for black pepper from the canned meat trade, particularly in the United States, plus the small margin between the market prices of black and white peppers.

Plate 2—Pepper growing on tree fern (balabala) supports, Naduruloulou

Photo—V. E. Sills

PREPARATION

It is not the purpose of this article to discuss the cultivation side of pepper production. This has been adequately dealt with elsewhere by Sandford and by Brown and Reader (1952).

As regards the processing of pepper there are three or four simple methods in current use in the main pepper producing countries which would be of interest to anyone intending to grow pepper in Fiji. The methods vary according to whether black or white pepper is required :—

(*a*) *Black Pepper*—The simplest method of preparing black pepper is to gather the spikes when only a few of the berries are ripe and red and to spread them out on mats in the sun to dry. The pepper needs to be turned frequently or trouble with mildew is sure to be experienced. In fact, unless sundrying conditions are good, damage from mildew is likely to be the main complaint.

A better method is to dip the freshly gathered berries, from which the stalks have been separated, in boiling water for a few minutes, following which they are spread out in the sun to dry. The boiling water treatment hastens the death of the berries and causes a rapid blackening of the skins ; drying is said to take place more rapidly under these conditions. The boiling treatment also renders the skins tougher and gives the pepper a better colour.

The alternative to sundrying is, of course, some form of artificial drying. In Indonesia, smoke sheds are commonly used in districts which are too wet to permit sundrying (private communication, 1957). One method used by Chinese consists of spreading freshly plucked spikes over the floor of the drying chamber to a depth of 6 to 12 inches ; water is then sprinkled over the layer of green pepper and the whole is covered over with gunny bags. A fire is lit beneath the slatted floor supporting the layer of pepper and, by covering the fuel with a layer of damp earth, is made to produce a large volume of smoke at a low temperature. The pepper is subjected to this treatment for 24 hours during which time it turns black. The gunny bags are removed and normal drying is allowed to take place, the pepper being completely dried in the course of a further 12 hours. The fire is extinguished at the end of this period and the pepper allowed to cool overnight. Finally, the berries are separated from the stalks by beating and winnowing and the pepper is then ready for export.

(*b*) *White Pepper*—Unlike black pepper, which is prepared from green berries beginning to turn yellow, the white product is made from completely ripe or bright red berries. It is very difficult to remove the husk or pericarp from peppercorns unless they are quite ripe so the regularity and care with which harvesting is conducted are important factors in white pepper production. If allowed to ripen too much the berries fall off and are easily lost.

The traditional method of decorticating the ripe berries is to place them in bags and to leave them in running water for 1 to 2 weeks. The skins are thereby softened and can easily be removed by rubbing the berries between the hands or by treading the berries with the feet. After the skins have been removed the smooth white kernels are carefully washed and then dried as quickly as possible on mats in the sun.

Another method of removing the skins consists of allowing a heap of ripe berries to ferment or " heat up " for 2 or 3 days. The skins can then be rubbed off easily under running water. Even small quantities can be prepared in this manner but the importance of selecting only the ripe berries cannot be overstressed ; underripe berries are hardly affected by the fermentation process.

Plate 3—Pepper in bearing, Naduruloulou
Photo—V. E. Sills

YIELDS

The yield of dry pepper from 100 lb. of fresh berries is given as 36 lb. of black or 24 lb. of white. The selling price of white pepper must therefore be at least one and a half times higher than that of black pepper in order to make it profitable to produce the white kind. As mentioned previously, the prices offered for white pepper in recent years have not always encouraged its production.

QUALITY

Good quality black pepper is of fairly uniform size and free from dust, stalks, leaflets, etc. This condition is achieved by garbling or winnowing the berries by hand in a flat wicker basket—or it may be done with the aid of machines.

Cleanliness and uniformity of size are even more important in white pepper ; and the very small dried immature fruits known by the trade as " pinheads " are particularly disliked. Such material as pepper husks and pinheads are suitable only for distillation.

A recent valuation by a London broker of Fiji-produced, sundried black pepper gave a price of 2d. or 3d. a lb. less than that for Borneo pepper. The difference in price was attributed to the indifferent method of preparation and not to the inherent quality of the pepper which was relatively good.

CHEMICAL CONSTITUENTS

The active constituents of pepper which provide its pungency consist of a group of alkaloids of which piperine and chavicine are the most important. The flavour and aroma are derived from an essential oil which may be obtained by distillation. By way of interest, small quantities of this essential oil of pepper are used by scent makers and it was once a common ingredient of medicines.

An analysis of freshly ground, sundried, black and white peppers grown at the Experimental Station, Naduruloulou, gave the following fairly typical results :—

	Moisture %	Crude Fat %	Crude Fibre %	Crude Ash %	Alcohol Extract %
Black pepper	12·9	6·4	9·9	6·1	8·9
White pepper	14·1	5·3	4·5	2·1	7·1

No legal standards for pepper exist in the United Kingdom but Australia, Canada, the United States and others have fixed certain limits for black and white peppers. The United States Federal standards, for example, define limits for non-volatile ether extract, starch, total ash and ash insoluble in hydrochloric acid. By comparison with the tables of analyses of genuine pepper, however, these standards are reasonably liberal and pepper producers should have no difficulty in marketing a pepper that will conform to them.

Plate 4—Pepper in bearing—a close-up view

Photo—V. E. Sills

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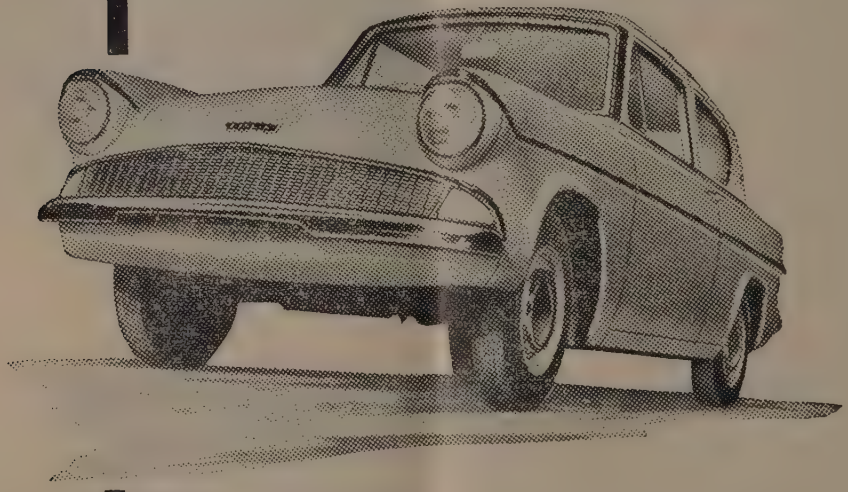

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NOTES ON WILDLIFE IN FIJI AND ITS CONSERVATION

BY J. M. WATSON

GENERAL

Under the *Birds and Game Protection Ordinance*, all indigenous birds, with the exception of certain game birds which may be shot during a short open season in prescribed numbers, and hawks which are treated as vermin, are strictly protected.

Under the *Fisheries Ordinance*, regulations lay down the size of nets which may be used, size limits of specified fishes, crab, turtles and trocas shell. The use of explosives and fish poisons is prohibited.

Under these Ordinances, voluntary rangers and wardens may be appointed by the Governor.

RESERVES

Under the *Birds and Game Protection Ordinance*, the Governor may declare *Game Reserves* in which it is an offence to shoot game birds (i.e. the three species of pigeon listed hereafter) at any time. At present the value of such reserves is doubtful as there are considerable tracts of country which are almost inaccessible and are therefore natural reserves. However, two Game Reserves have been declared under this Ordinance.

Under the *Forest Ordinance*, the Governor may declare *Nature Reserves* in which all forms of animal and plant life are inviolate. Several *Nature Reserves* have already been declared, covering an area of some 14,000 acres. Owing to lack of staff and funds it has not been possible to undertake the study of, and research into, matters relating to the fauna and flora of these reserves and the physical conditions in which they live.

ANIMAL LIFE

(*a*) *Mammals*—There are only three indigenous land mammals :—

Flying Fox, *Pteropus tongabus tonganus*.
(Range of Species : S.W. Pacific).

Long-tailed Fruit Bat, *Notopteris macdonaldi*.
(Range : Melanesia).

Sheath-Tailed Bat, *Emballonura s. semicaudata*.
(Range : Fiji, Samoa, New Hebrides).

Although the fruit bats are eaten by the Fijians, none of the above is in any danger of extinction. The following mammals have been introduced :—

Indian Mongoose (1883) on the two largest islands only (Viti Levu and Vanua Levu). Introduced to control rats in sugar cane, now a complete pest responsible for destruction of ground nesting birds, etc.

Sambar Deer (sub-genus *Rusa*) introduced possibly from Noumea on to one small island only—Wakaya (c. 1900). Has become a pest there, particularly among young coconuts.

Polynesian Rat (*Rattus concolor* group). Probably arrived here with the early Melanesian travellers. Can be harmful in restricted areas. Widespread.

(*b*) *Birds*—Under the *Birds and Game Protection Ordinance*, the following game birds may be shot during the open season (one month—May) :—

Pacific Pigeon (*Ducula p. pacifica*). (Ruve).
Range : Central Polynesia.

Peale's Pigeon (*Ducula latrans*).
Range : Fiji Group.

White Throated Pigeon (*Columba v. vitiensis*). (Soqi).
Range : S.W. Pacific with sub s. *vitiensis* in Fiji.

In suitable localities the above are fairly common but their numbers would be rapidly depleted if the open season were to be extended. In the past, a number of other birds were scheduled as game birds, including the Australian Grey Duck (*Anas superciliosa pelewensis*). These are now given complete protection. It is hoped that the Grey Duck is now increasing in numbers.

The following birds, it is believed, have entirely disappeared (probably by the turn of the century) from the Fiji Group. Their disappearance is likely to be due to a number of causes including trapping, hunting with dogs, shooting, ravages of the mongoose and rats :—

Whistling Tree Duck. *Dendrocygna arcuata*. (*Ga*—all ducks.)

Widespread in many parts of the Pacific from the Philippines to Australia.

Paradise Shelduck. *Tadorna variegata*.

Range : New Zealand, evidence of its one-time existence in Fiji is slender.

Incubator Bird. *Megapodius pritchardii*.

Range : central Polynesia, occurs on Niuafoo I. (Tonga Group) between Fiji and Samoa.

Barred-Wing Rail. *Nesoclopeus poeciloptera*. (*Tiri*—all rails.)

Restricted to Viti Levu, the largest island. Not found for more than 50 years.

(NOTE.—all ground nesters.)

The following birds are rare and their status in Fiji not fully known :—

Peregrine Falcon. *Falco peregrinus nesiotes*. (*Ga-ni-vatu* (?)).

Range : S.W. Pacific. Recorded with certainty from Viti Levu and Taveuni.

Domestic Fowl. *Gallus gallus* (Toa (?)).

Many islands of the Fiji Group but decimated by mongoose on the larger islands.

Sooty Rail. *Porzana t. tabuensis*.

Range : S.W. Pacific. Recorded from Viti Levu, Ovalau, Ngau and Kadavu.

White-Browded Rail. *Poliolimnas cinereus*.

Range : S.W. Pacific. Very rare in Fiji, only recorded from these islands, Viti Levu, Ovalau, Ngau.

Red Throated Lorikeet. *Vini amabilis*.

Range : three islands of Fiji only, Viti Levu, Ovalau and Taveuni.

Grass Owl. *Tyto longimembris*. (*Lulu*—all owls).

Range : Fiji (Viti Levu) and New Caledonia.

Long Legged Warbler. *Trichocichla rufa*.

Range : Fiji (Viti Levu) only. Not recorded for many years.

Possibly the most interesting bird of the Fiji Group is :—

Silktail or Satin Flycatcher *Lamprolia victoriae*. (*Sesi*.)

Known only from the two islands, Taveuni and Vanua Levu of Fiji. Family uncertain. Not uncommon.

All the above, being indigenous birds, are strictly protected. (Except, presumably, the Peregrine Falcon which, being a hawk, is excluded from the protected list—drawn up in 1923 !)

A number of birds imported from Asia, including the Red-vented Bulbul (*Pycnonotus cafer*, and the Indian Myna, *Acridotheres tristis*, have undoubtedly been responsible for driving the indigenous birds from inhabited and cultivated areas. The Bulbul can play havoc in an orchard. Other imported birds, the Malay Turtle Dove, *Streptopelia chinensis tigrina*, (from Asia), the Java Rice Sparrow, *Padda o. oryzivora* (from Indonesia, as a cage bird), and the Strawberry Finch or Astrild (*Estrilda* sp.) (from Australia—as a cage bird in the first place), may be responsible for considerable damage to crops. The cheeky Australian Magpie (*Gymnorhina tibicen*) was introduced into

Taveuni in the belief that it would control the stick insect, a pest of the coconut palm. It certainly devours those that it can reach. The European Starling (*Sturnus vulgaris*) has managed to land on Ono-i-Lau and Vatoa presumably from New Zealand, probably between 1920 and 1930 via the Kermadec Islands, and has become a pest. The Agricultural Department, by vigorous campaigns of destruction, has managed to prevent its spread northwards and to keep its numbers in reasonable bounds but it has not by any means exterminated it.

Over the years a number of other bird introductions have been made. A specimen of the Australian Swamp Quail (*Synoecus ypsilophorus*) was recently shot (1958) in Viti Levu, and it is assumed that these were introduced some years ago. It has probably had an uphill fight with rats and mongoose. As far as is known, this is the only species of quail likely to occur in the Group.

(*c*) *Reptiles and Amphibians*—Land snakes uncommon and their number undoubtedly reduced by thoughtless destruction and by the mongoose.

Pacific Boa. *Enygrus* sp. (including *Enygrus bibonii*).
Pacific generally. (*Gata.*)

Fiji Snake (poisonous—an Elapid). *Ogmodon vitianus.*
Rare and seldom seen. Restricted to Fiji. Persecuted by Fijians and mongoose. (*Bolo.*)

The Banded Iguana, *Brachylophus fasciatus* (Vokai) is of great interest, being known only from Fiji and Tonga. It is a member of the family Iguanidae, which with the exception of this one strange genus and its single species from Fiji, and two, also quite out of place, from Madagascar, is entirely American. This queer creature should undoubtedly receive full protection as it is persecuted by the Fijians and probably preyed upon by the mongoose.

One or two species of Gecko (including the Sad Gecko, *Lepidodactylus lugubris*), are common, but the reported occurrence of Agama lizards in Fiji requires confirmation. The unwelcome Estuarine Crocodile (*Crocodylus porosus*) has been recorded occasionally from Fiji (See "The Fiji Islands"—page 158). A record of the appearance of a Long-necked Water Tortoise (*Chelydidae*) in Fiji requires checking.

Turtles are not uncommon (Loggerhead, Green and Hawksbill). Under the *Fisheries Ordinance*, paragraph 17, it is an offence to dig up, use, take or destroy turtle eggs of any species or in any way molest, take or kill any turtle the shell whereof is less than 8 inches in length, or during the months of January, February or December in any year in any way molest, take or kill any turtle of any size.

The possibility of establishing breeding pens and nurseries for young turtles would certainly be explored were staff and funds available.

At least two members of the family *Ranidae*, *Cornufer dorsalis* and *Platymantis vitianus*, are known from the Group but nowhere appear to be really abundant.

The Surinam Toad (*Bufo marinus*) was introduced from the West Indies (via Hawaii) in 1936 to control slugs, beetles, etc. It has multiplied greatly, undoubtedly consumes vast numbers of harmful insects, but has lost size. It probably provides food for the mongoose also.

(*d*) *Fish*—In certain areas, especially near towns and river mouths, intensive reef-shore fishing has depleted the fish population. Under the *Fisheries Ordinance*, the Governor in Council may prescribe areas and seasons within which the taking of fish is prohibited or restricted but no such areas have as yet been prescribed.

No fish fence or other obstruction device of a permanent or semi-permanent nature may be erected or operated in any stream, river or estuary (except by local indigenous Fijians taking fish for their own personal consumption). No nets other than hand nets and cast or throwing nets are permitted for the taking of fish in an estuary of any river or in the sea within a hundred yards of its mouth.

The meshes of every form of net except those specifically used for taking prawns, white bait and sardines (*Clupeidae*) may not be less than 2 inches stretched measure. For fresh water prawns (*Palaemon*) and sardines the net may not be under 1 inch stretched measure. The meshes of basket traps and fish fences are also stipulated.

The following size limits are in force :—

Grey Mullets *Mugil* species ..	8″ (*Kanace*)
Mackerel (*Scomber brachysomus*) .	6″ (*Salala*)
Rock Cods and Groupers (*Serranus* species)	6″ (*Donu, Kawakawa*)
Ketang (*Siganus vermicula'tus*) ..	6″ (*Nuqa*)
Surmullets or Whisker Cod (*Mullidae species*)	6″ (*Kake, Ki, Ose*)
Pouters (*Gazza minuta Leiognathus* species)	5″ (*Kaikai*)

In many rivers, fresh water fish are conspicuous by their absence although the "Ika Droka" of the Fijians (*Kuklia rupestris*), a member of the Glass Perch family (*Chandidae*), is at home in fresh water and provides some sport, large specimens exceeding three pounds. Some eight years ago the Agricultural Department introduced the Mossambique Bream (*Tilapia mossambica*) which have multiplied exceedingly and provide excellent food. About a year ago the Murrel (*Ophicephalus striatus*) was introduced from S.E. Asia but it is too early yet to state whether it has fully established itself.

Suggested introductions for the future include the Nile Perch (*Lates albertianus*) and various other species of *Tilapia* (e.g. *zilli*).

(*e*) *Crabs, shellfish, etc.*—Under the *Fisheries Ordinance* it is an offence to take, kill, sell or expose for sale the Edible Crab (*Scylia serratus*) (*Qari dina*) of less than four inches measured across the widest part of the carapace or shell, and any female of this species carrying eggs.

Within the last few years there was reason to believe that the population of the Trocas Shell (*Trochus niloticus*) (*Sici*) was being markedly depleted. For many years it was an offence to take, sell or be in possession of trocas shell measuring less than $2\frac{3}{4}$ inches across the mouth whorl. Recently (1959) the size limit was increased to $3\frac{1}{2}$ inches on the advice of the Fisheries Officer of the South Pacific Commission. The trocas is used for the manufacture of buttons and shell ornaments.

BOTANY . . .

THE GERMINATION OF BATIKI BLUE GRASS SEED

BY J. W. PARHAM

The results of a few preliminary tests carried out on Batiki Blue grass (*Ischaemum indicum*) seed were given in an article in Volume 27 of the *Agricultural Journal* at the time when the acquisition of a seed germination tester was recorded (Parham, 1956).

Two series of tests have been carried out since June, 1956, and the results of this project (Grass 1/56) are given below. The seeds were tested at a constant temperature of 35°C and, altogether, four hundred and fifty samples, each of four hundred seeds, were tested.

SUMMARY OF RESULTS

1. The germination rate of Batiki Blue grass seed reaches a peak between eight and ten months after harvesting.
2. The germination rate is satisfactory between the fifth and tenth months and seed should not be sown before it is five months old.
3. The germination rate of seed stored in cloth bags drops very rapidly after the tenth month.
4. Seed stored in air-tight containers drops gradually after the tenth month but still gives a reasonable percentage germination up to eighteen months and some germination up until twenty-four months.
5. Seed should be harvested a few days before it is fully mature (and liable to fall when handled), and it should be left in a dry place for two or three days before it is threshed to allow it to mature as much as possible on the stalk.
6. The seed should be thoroughly dried and stored in the driest place available.
7. The average germination rate of seed which has been harvested as close as possible to maturity, and which has been properly dried and stored, is 20–25 per cent between the fifth and tenth months.
8. Hand-picked mature seed has given a maximum germination rate of 55 per cent.
9. Freshly harvested seed has a low germination rate and germinates over a period of three weeks ; seed which has been stored for five months or more germinates during the first three or four days of the test.
10. There is no indication that there are any significant differences on the germination rates of seed collected from Naduruloulou, Dobuilevu and Nadi.

The graph (figure 1), derived from all the tests carried out, shows the results which can be expected from good average seed.

A similar series of tests is at present being carried out on Nadi Blue grass (*Dichanthium caricosum*) seed.

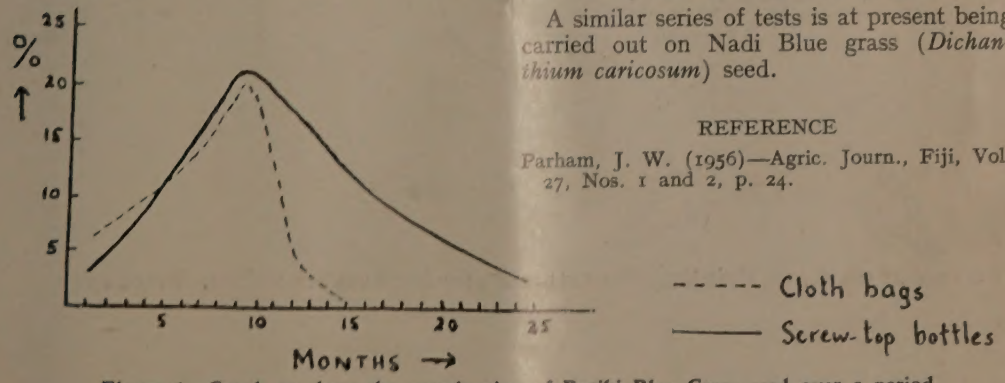

Figure 1 Graph to show the germination of Batiki Blue Grass seed over a period of two years, using two different methods of storage

REFERENCE

Parham, J. W. (1956)—Agric. Journ., Fiji, Vol. 27, Nos. 1 and 2, p. 24.

Gardening in Fiji

(Formerly "Gardening Notes")

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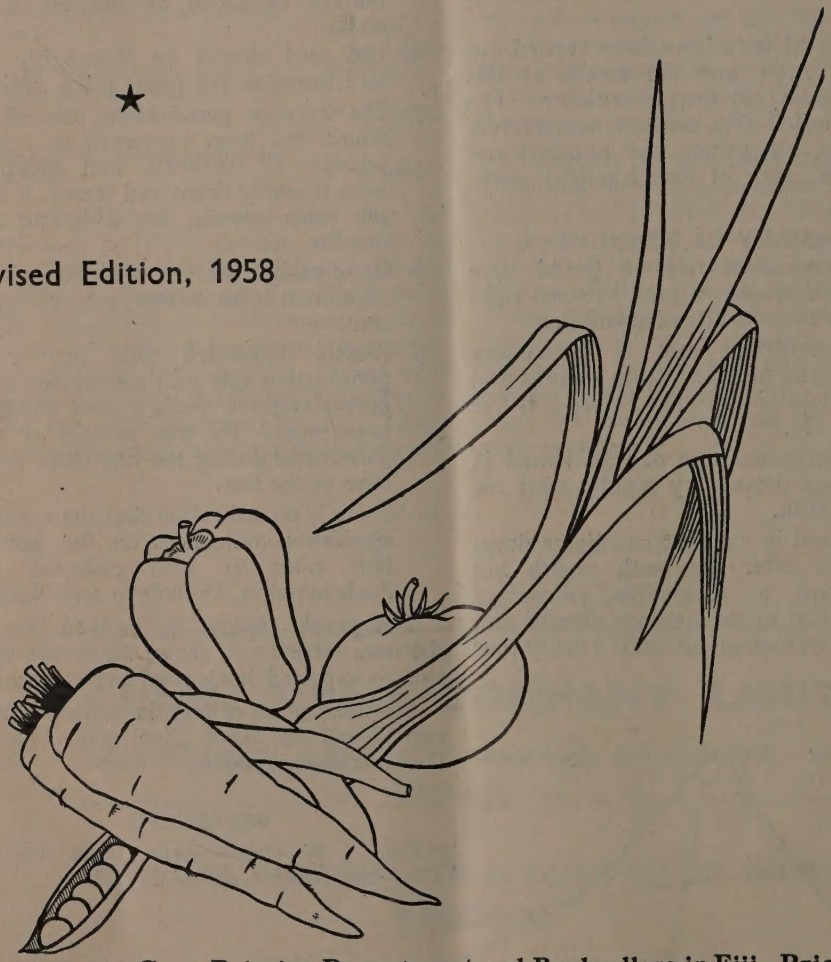
Revised Edition, 1958



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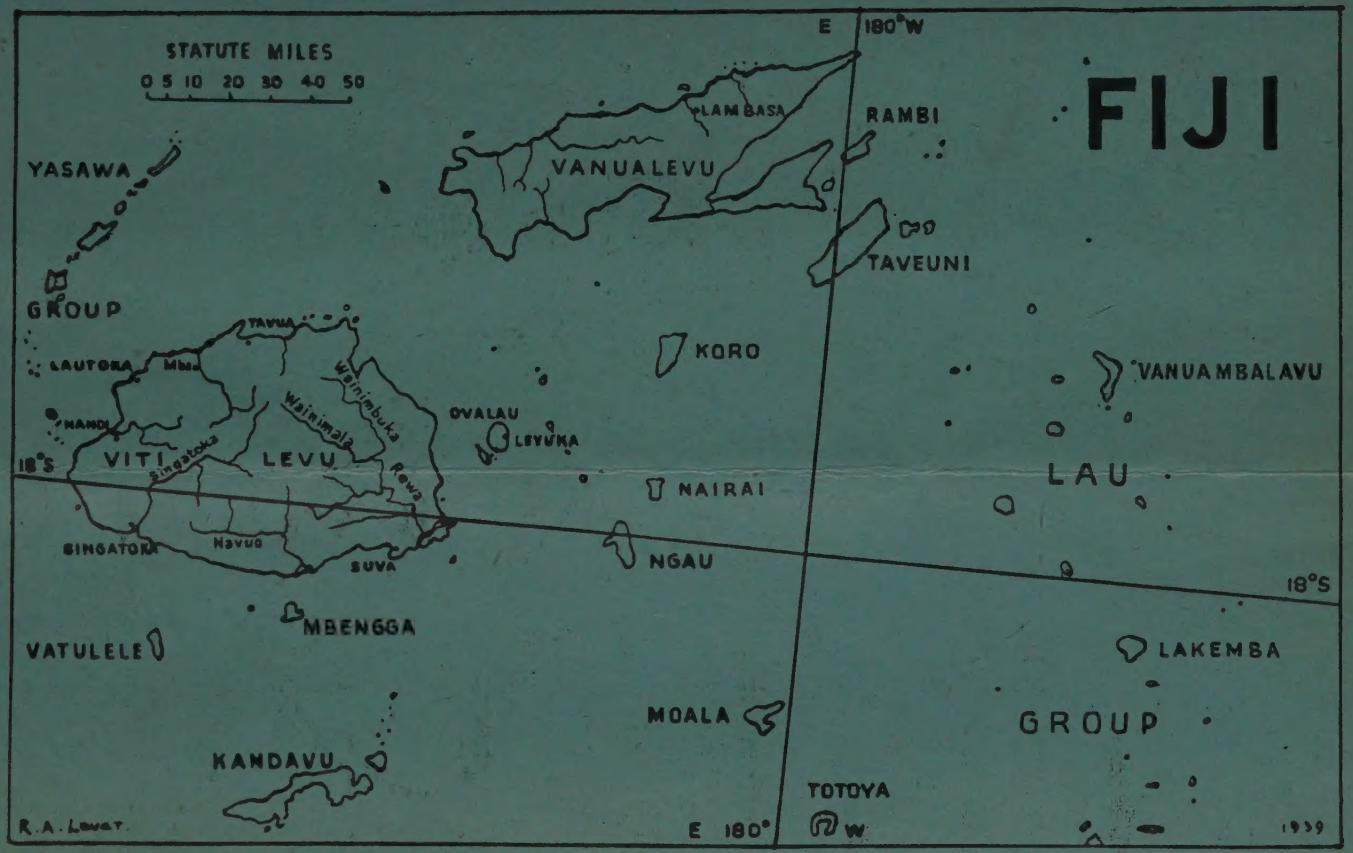

So as to include Kadavu and Totoya within the framework available the map has been rotated some 6° to the east

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